Policy Issues on White Roofs:
Heat Islands, Public Health, and Global Warming

Brazil-Mexico Policy Discussion
Lawrence Berkeley National Lab
February 25, 2013

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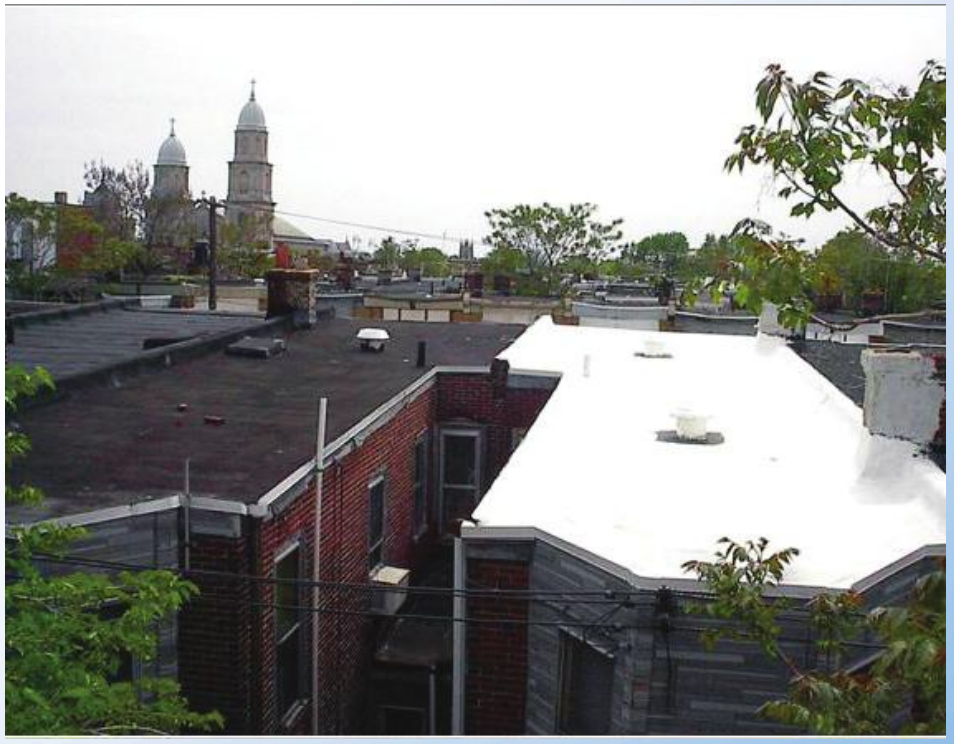
July 1995: Chicago Heat Wave

- 739 reported* deaths (highest risk group lived on the top floors of buildings with black roofs)



* More than 250 additional deaths not autopsied

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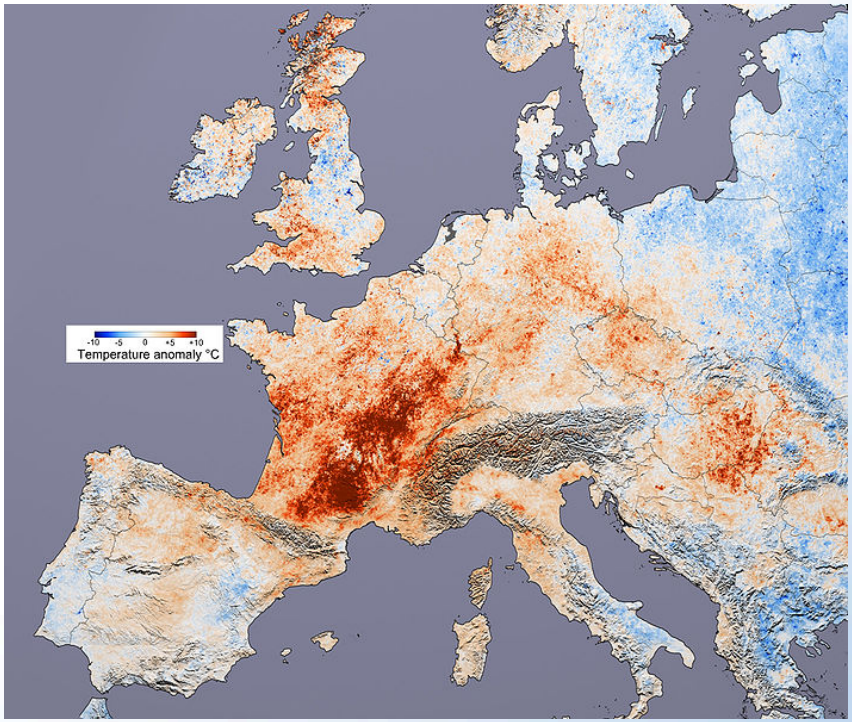
August 2003: European Heat Wave

- Temperature anomalies reached 10°C
- 52,000 Europeans died—18,000 Italians (2006 assessment)

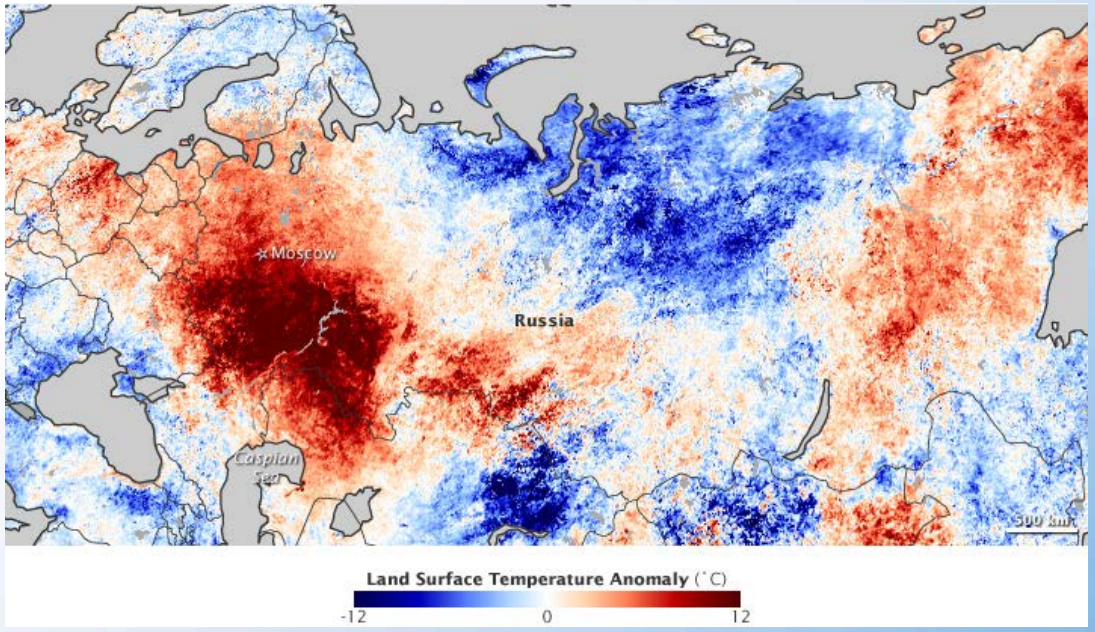


http://earthobservatory.nasa.gov/IOTD/view.php?id=3714

Country	Fatalities
Italy	18,257
France	14,802
Germany	7,000
Spain	4,130
England & Wales	2,139
Portugal	2,099
Smaller countries	4,025
Total of above	**52,452**

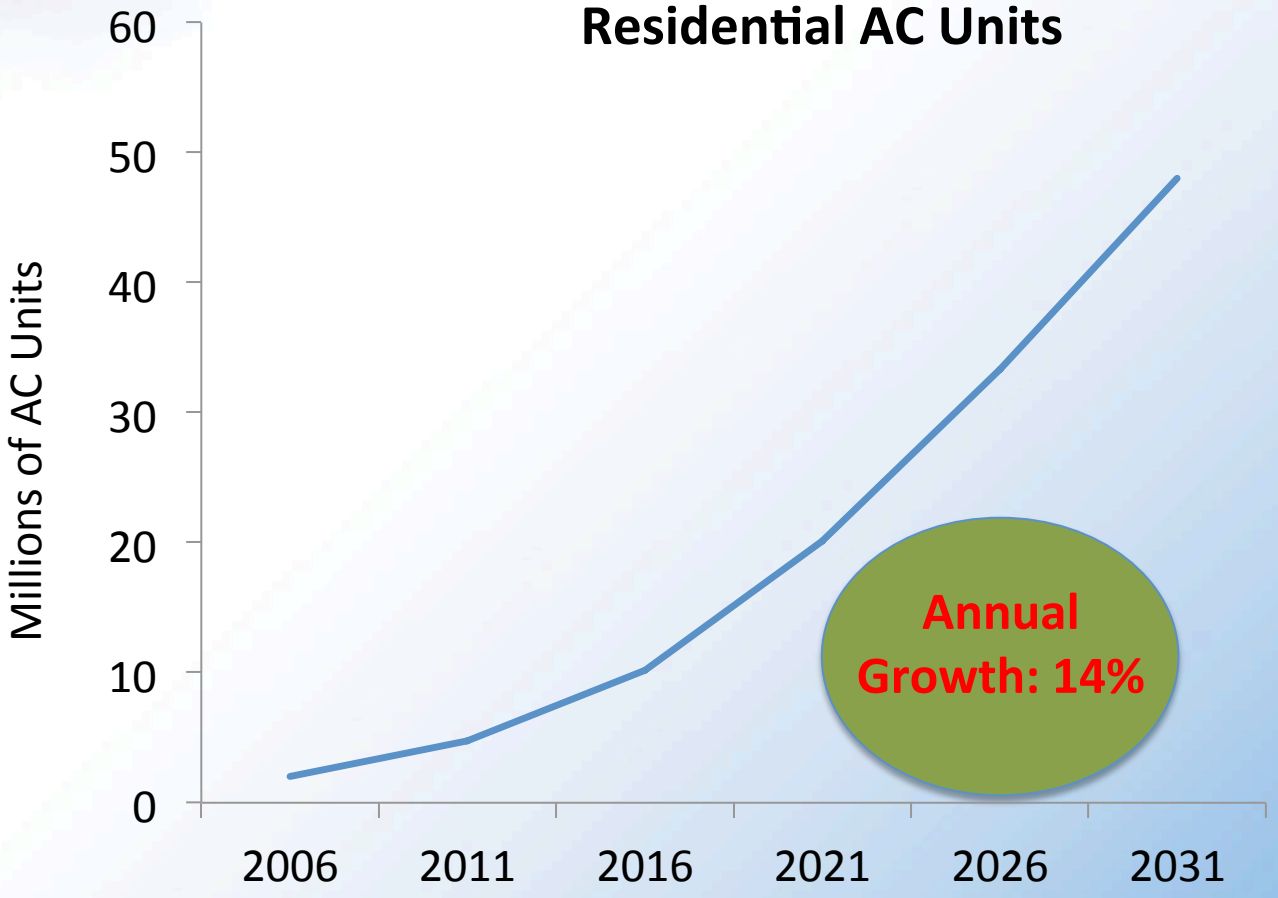
2010: Russian Heat Wave

- Centered Southeast of Moscow
- Temperature anomalies reached 12°C
- 10,000-15,000 deaths



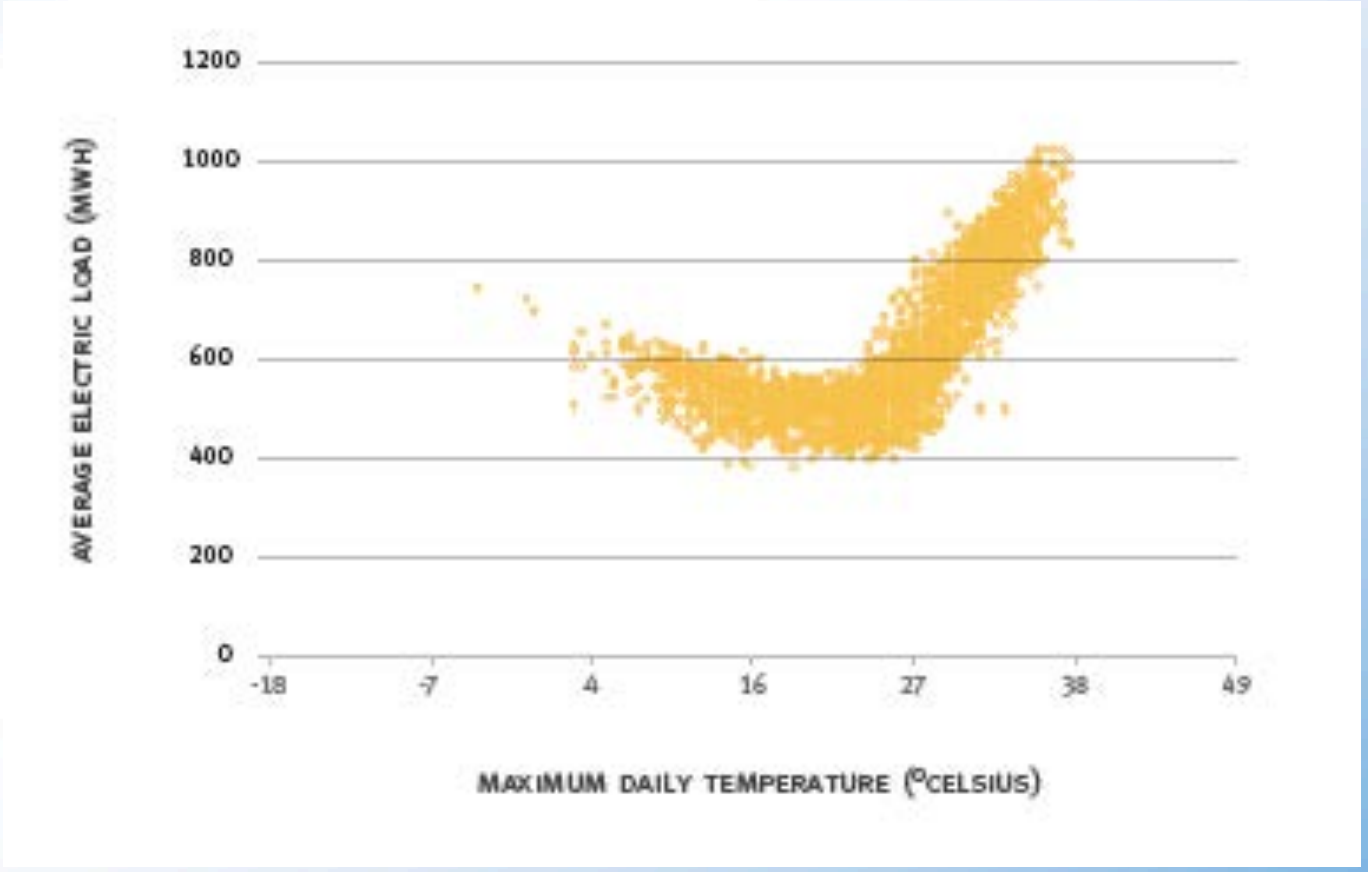
http://takvera.blogspot.com/2011/10/climate-change-fractional-attribution.html

New AC Load: India



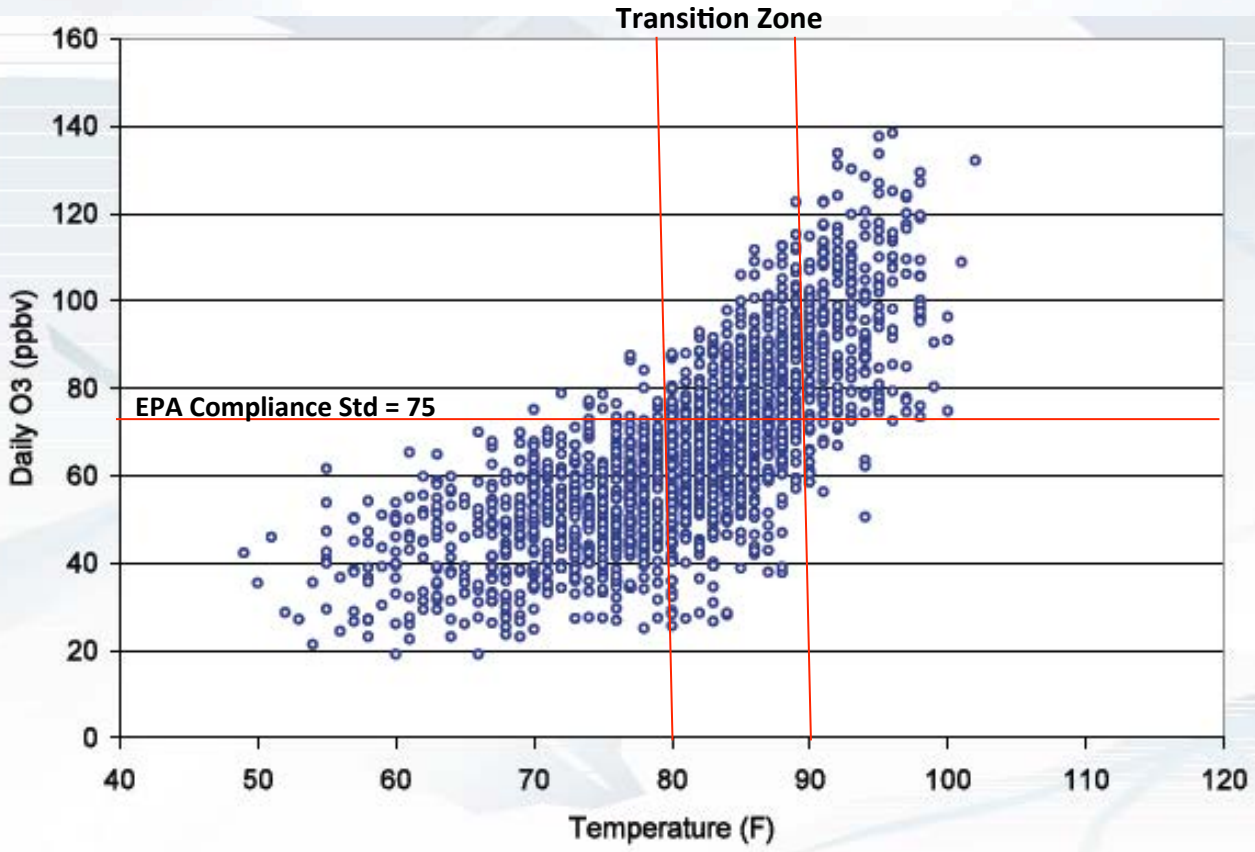
Source: World Bank

Temperature and Electricity Load



Adapted from Sailor, D. J. 2002. Urban Heat Islands, Opportunities and Challenges for Mitigation and Adaptation. Sample Electric Load Data for New Orleans, LA (NOPSI, 1995). North American Urban Heat Island Summit. Toronto, Canada. 1–4 May 2002. Data courtesy Entergy Corporation.

Temperature and Smog Formation



Maximum surface temperature at BWI versus peak 8-hr ozone concentrations in the Baltimore non-attainment area for the period May-September, 1994-2004 (Piety, 2007).

Source: Maryland Commission on Climate Change

Cooling our Planet

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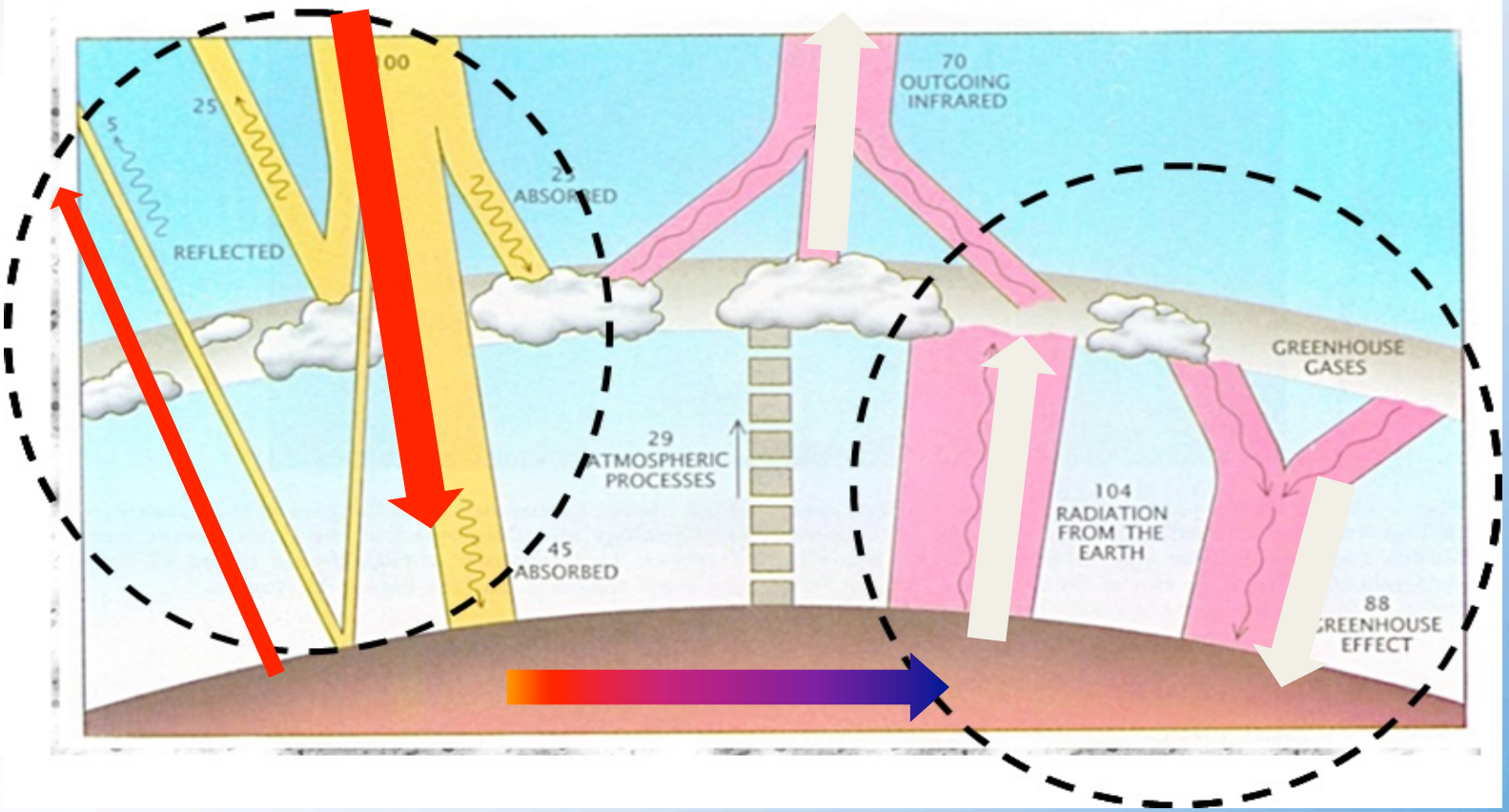
Solar-reflective surfaces cool the globe via "negative radiative forcing"



Source: Intergovernmental Panel on Climate Change (IPCC)

Global Cooling

- Whitening 100 m^2 (~1000 ft^2) of gray roofing cancels out the **emission** of 10 t of CO_2

How much CO_2 equivalent is offset if we whiten all eligible urban flat roofs worldwide? (i/ii)

- Answer: **24 Gigatonnes (Gt)**
  - 2/3 of a year's worldwide emission
  - Gigatonne = billion metric tons

- If implemented over 20 years (the life of a roof or a program) this is ≈ 1.2 Gt/year

How much CO_2 equivalent is offset if we whiten all eligible urban flat roofs worldwide? (ii/ii)

- Offset is equivalent to **taking half the cars in the world off the road for 20 years**.
  - There are about 600 million passenger cars world wide, and they each emit ≈ 4 t CO_2/year.

In terms of avoided power plants

- Full white roof potential avoids 500 medium-sized coal fired power plants or 1,000 medium-sized gas fired power plants
- For comparison, global power plants emit annually ~15 Gt CO2, equivalent to the output of 6,000 typical midsized power plants (2/3 coal, 1/3 gas)
- Further comparison – the real avoided emissions from global CFL deployment is equivalent to 400 power plants.

Addressing Urban Heat Islands Help to Achieve Goal of Sustainable and Resilient Urban Areas

Building Scale

- Up to 20% reductions in cooling demand on top floor.
- Improved thermal comfort and productivity in unconditioned buildings (e.g., homes, warehouses etc.).
- Longer lasting roofs.

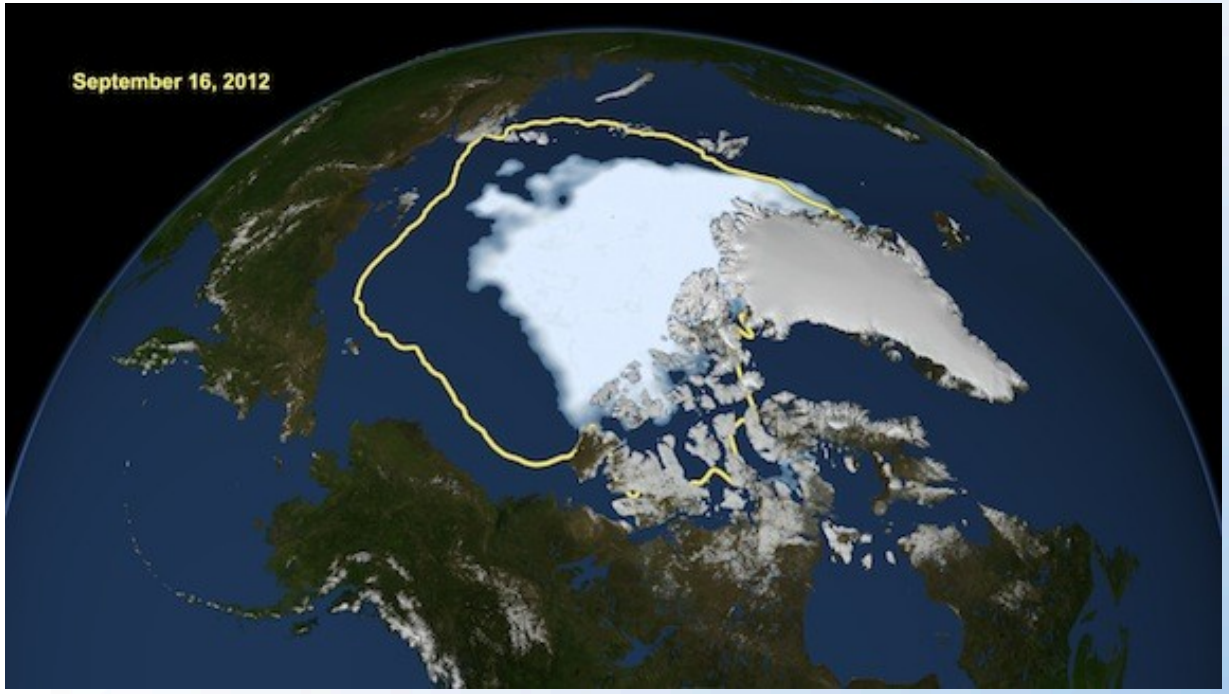
Urban Scale

- Improved air quality – a $10 billion energy and health cost reduction opportunity in the U.S. alone per year.
- Reduced peak electricity demand and avoided adoption of air conditioning.
- Greater resiliency to heat events and climate change.

Global Scale

- Offset the warming effect of 24 gigatons of CO_2 – equivalent to taking 500 coal power plants offline for 20 years.
- Every 10 square meters of white roof = 0.5 tons of CO_2 offset per year.

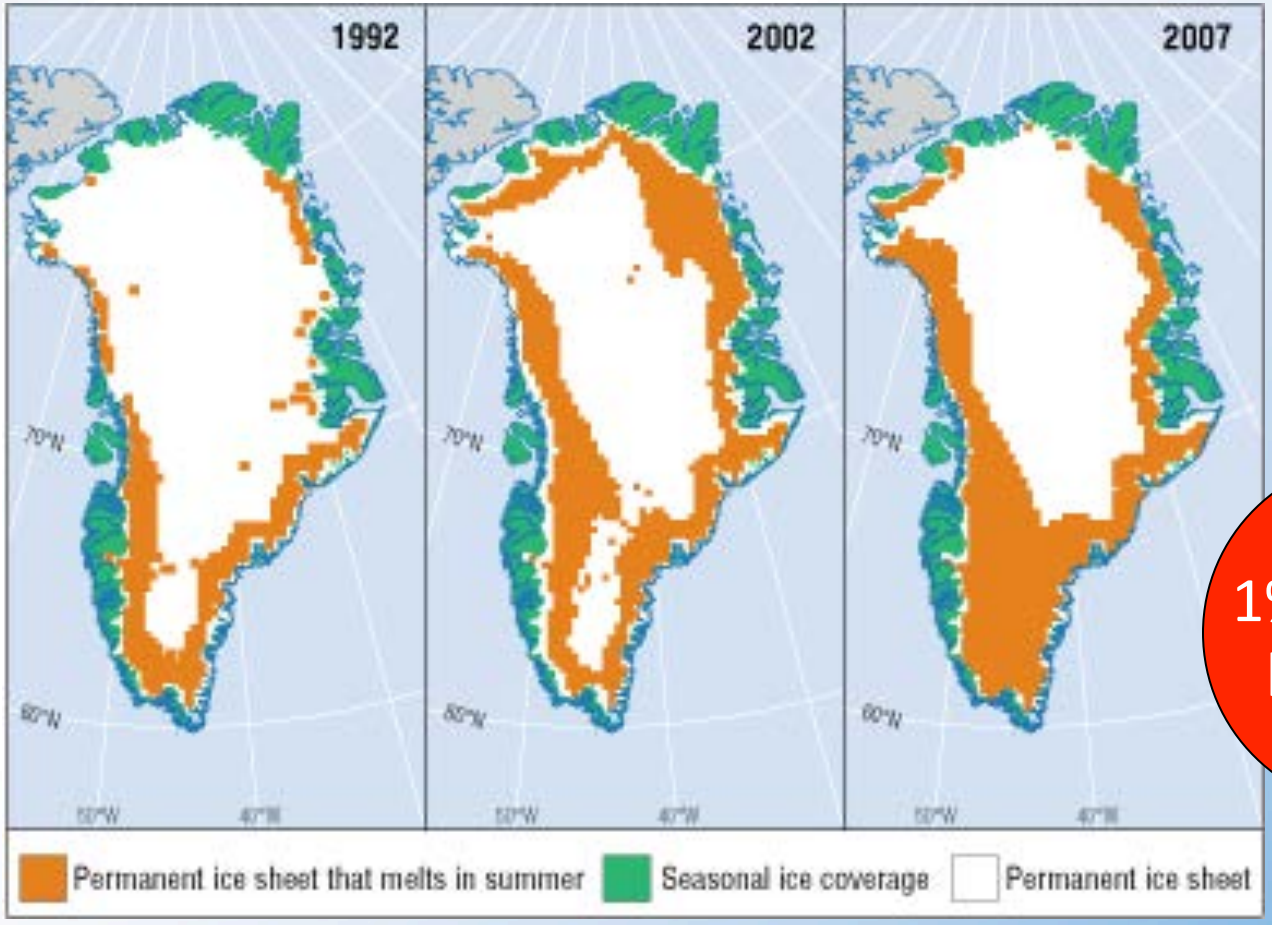
Arctic Sea Ice in Greenland



http://weather.aol.com/2012/11/29/area-of-arctic-sea-ice-larger-than-us-melted-this-year/

- Summer sea ice shown at center in white
- 1979-2000 average perimeter shown by yellow line
- Has nothing to do with power plant emissions, but we need all that missing albedo

Permanent ice sheet has melted substantially



1% of world land area

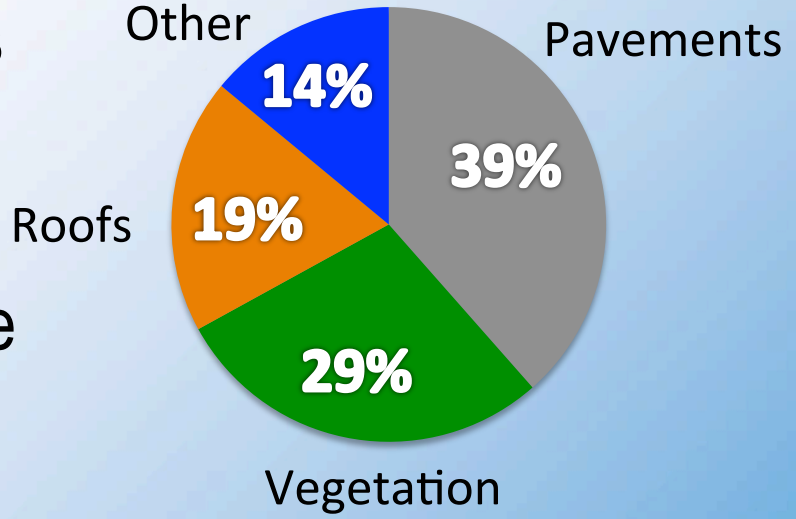
(Comparable to global urban space)

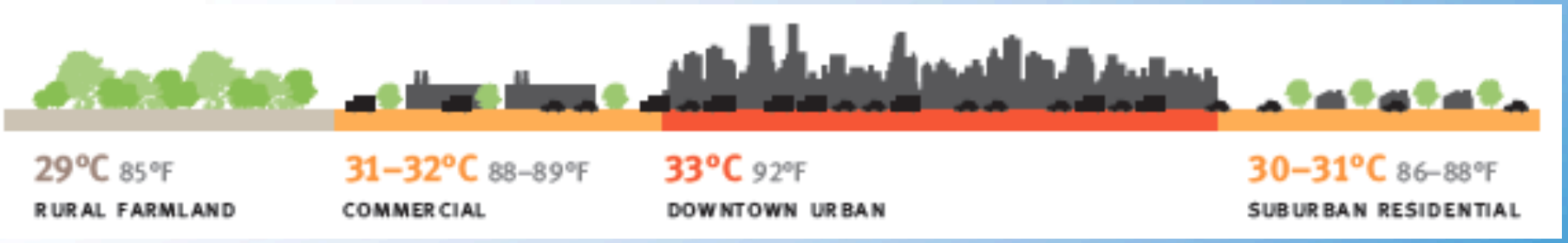
http://hungerreport.org/2010/report/chapters/four/making-the-connections

Urban Heat Island Effect

- Human activity, combined with dark roofs and pavements, make cities hotter than surrounding rural areas
- Higher temperatures lead to greater energy use, lower air quality, and a reduced quality of life in urban areas

Urban fabric above tree canopy





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White Roofs Around the World

www.ArtRosenfeld.org

A Real-World Example of Cooling

The whitewashed greenhouses of Almeria, Spain have cooled the region by 0.8 degrees Celsius each decade compared to surrounding regions, according to 20 years of weather station data.

Source: Google Earth

…in Santorini, Greece

…in Hyderabad, India

…and widely in the state of Gujarat, India.

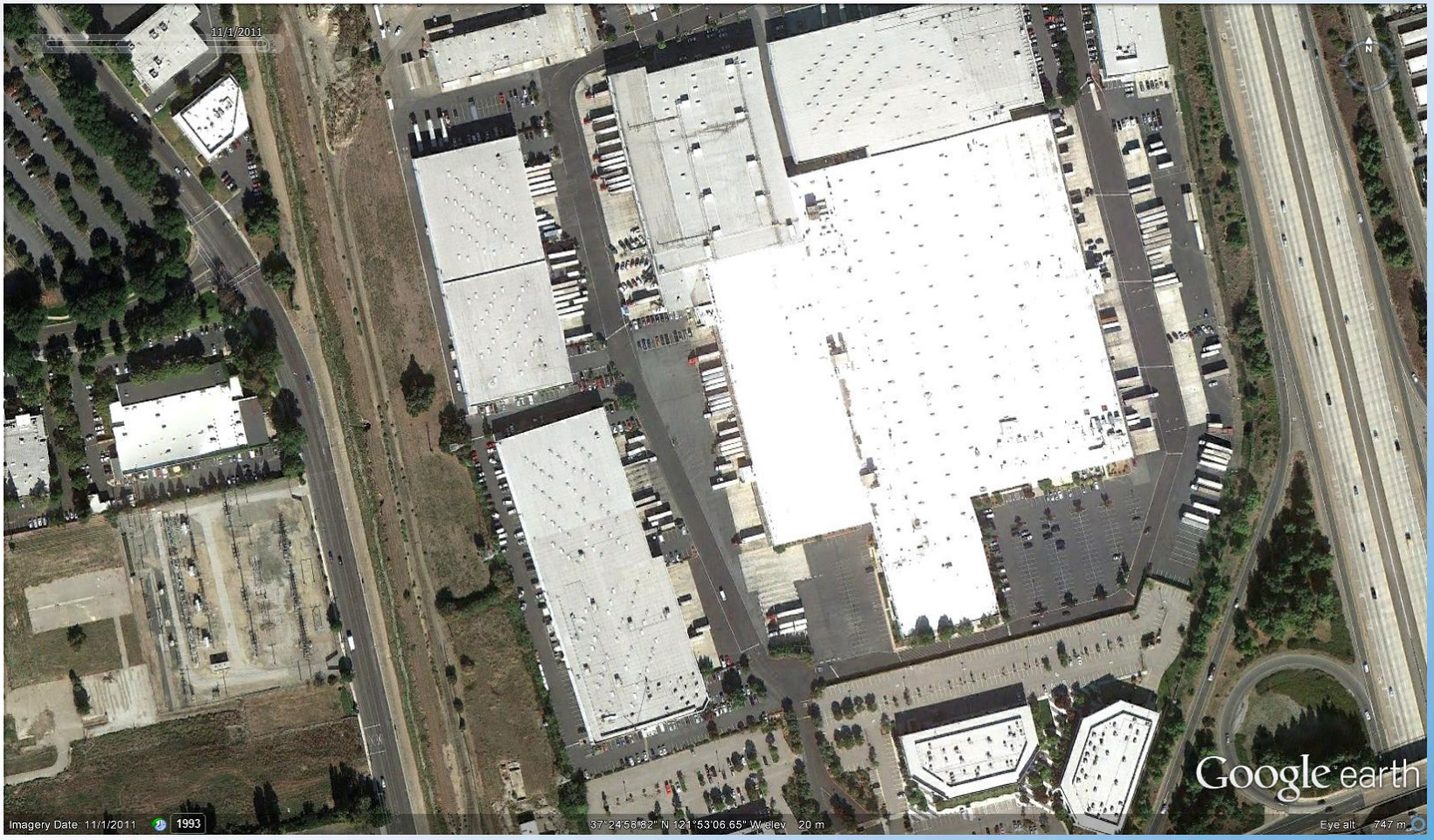
Walmart store in Northern California, ~2006

UC Davis switched to white membranes ~1980

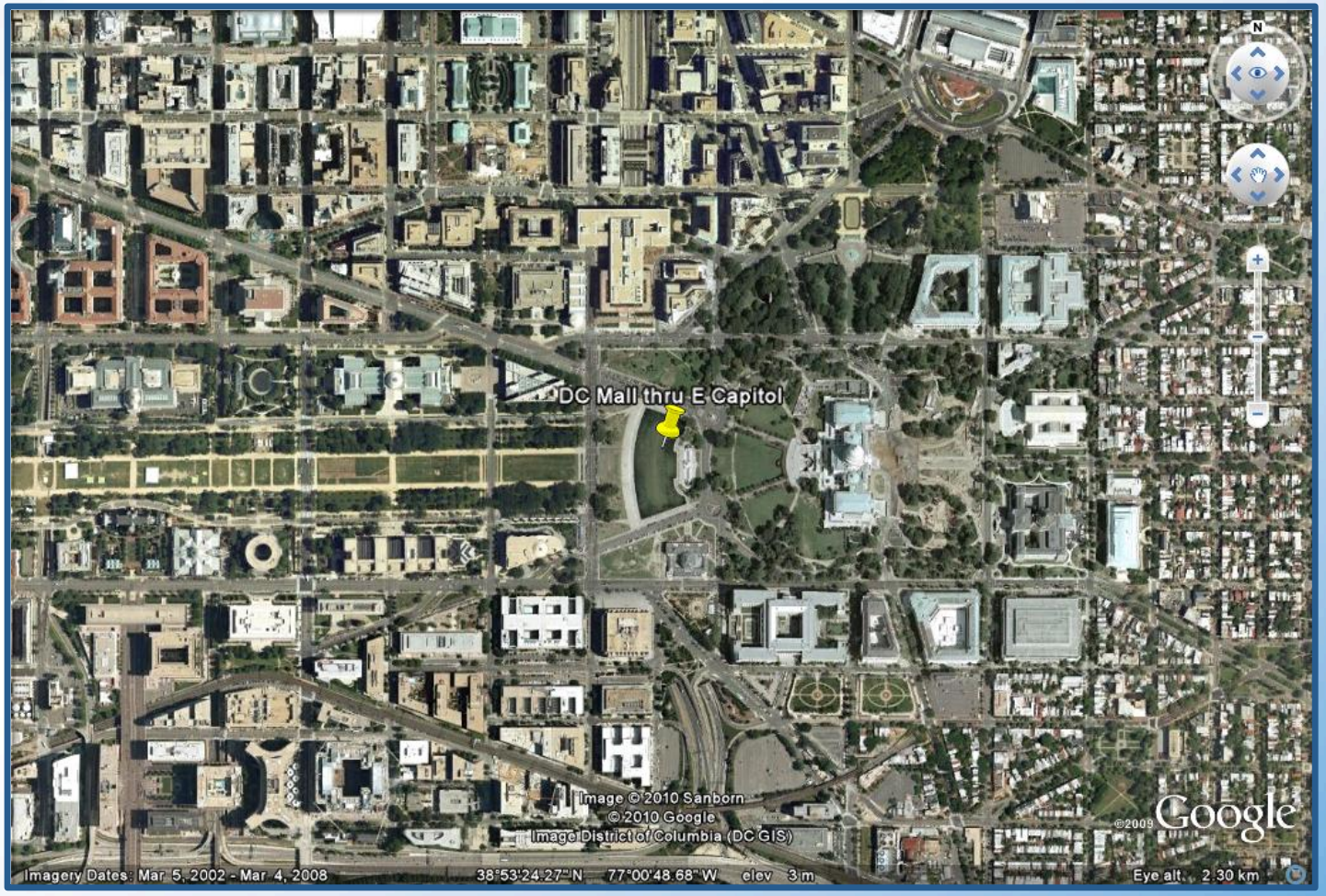
…and some are still in service today

San Jose, CA – 1993

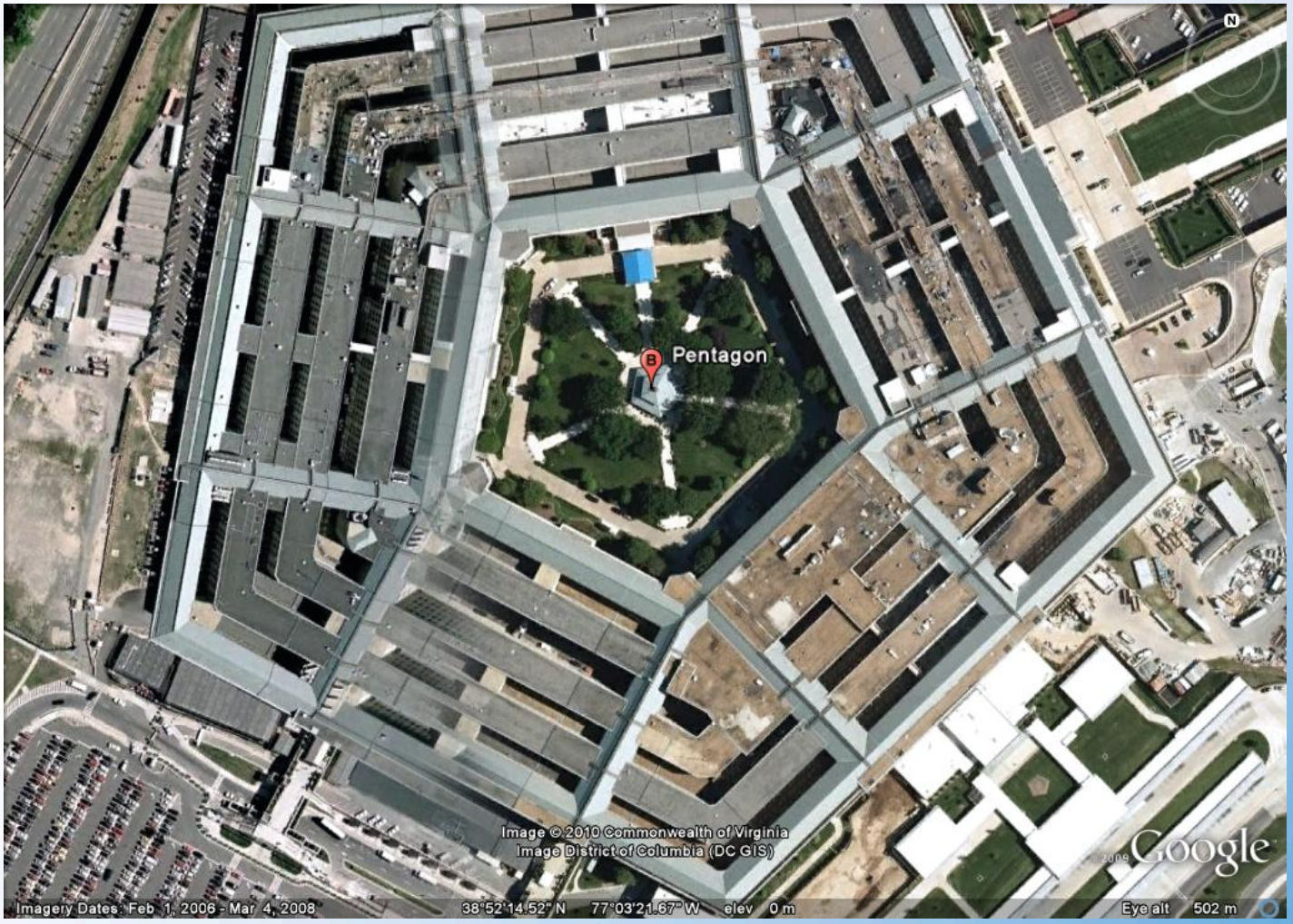
San Jose, CA – 2011



Washington, DC (Federal) has problems with historical buildings



Pentagon


Pentagon
Image © 2010 Commonwealth of Virginia
Image District of Columbia (DC GIS)
Google
Imagery Dates: Feb 1, 2006 - Mar 4, 2008
38°52'14.52" N 77°03'21.67" W elev 0 m
Eye alt 502 m

What to do Now

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Progress in energy efficiency standards

- In 2005, California's "Title 24" energy efficiency standards prescribed white surfaces for low-sloped roofs on commercial and large residential buildings (apartments, hotels, etc.). Several hot states are following.
- In 2008, California prescribed "cool colored" surfaces for steep residential roofs in its 5 hottest climate zones, but not yet Los Angeles.
- **Other U.S. states & all countries with hot summers ought to follow.**

Recent cool roof progress
(2005 – 2012)

- 2005
  - California Title 24 – "Flat roofs shall be white" (15 out of 16 climate zones). Walmart adopts white roofs for all stores.
  - EPA ENERGY STAR lists cool roof materials
- 2010
  - June 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
  - June 16th, 2010 – Marine Corp follows suit, Pentagon GSA following.
  - June 19th, 2010 – *RetroFIT Philly* announces winner of "coolest block" contest to white-coat black roofs of row houses.
- 2011-12
  - 100 Cool Cities launched – see www.GlobalCoolCities.org
  - 2012--US launched, at G20 Energy Ministers meeting, a voluntary Cool Roofs Working Group, and offers technical assistance to "charter" developing countries: India, Japan, Mexico, & US joined (further discussions with Brazil, China, South Africa)
  - New York City and Chicago adopt "If it's flat it shall be white or green"

Still to come

- Model codes will be modified to prescribe “flat roofs shall be white”
  - ASHRAE for commercial buildings
  - IECC for residential buildings
- But states and cities must still ***adopt*** model codes

Resources on the web

- LBNL – Heat Island Group
  - HeatIsland.LBL.gov
- Global Cool Cities Alliance
  - www.GlobalCoolCities.org
- Cool Roofs and Cool Pavements Toolkit
  - www.CoolRoofToolkit.org
- Art Rosenfeld's website
  - www.ArtRosenfeld.org

LAWRENCE BERKELEY NATIONAL LABORATORY PRESENTS:
SCIENCE AT THE THEATER

COOL CITIES, COOL PLANET

Cool Colors

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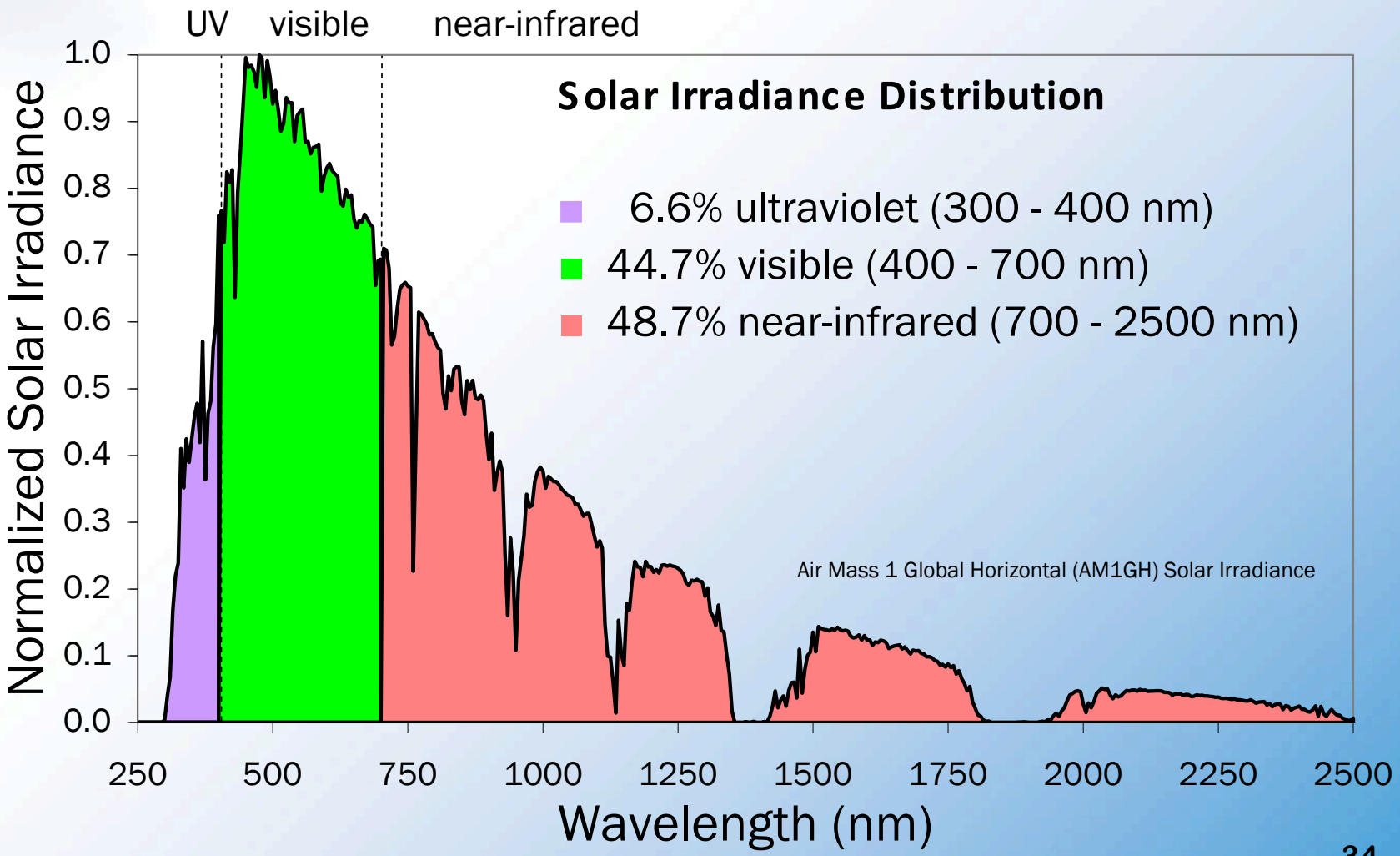
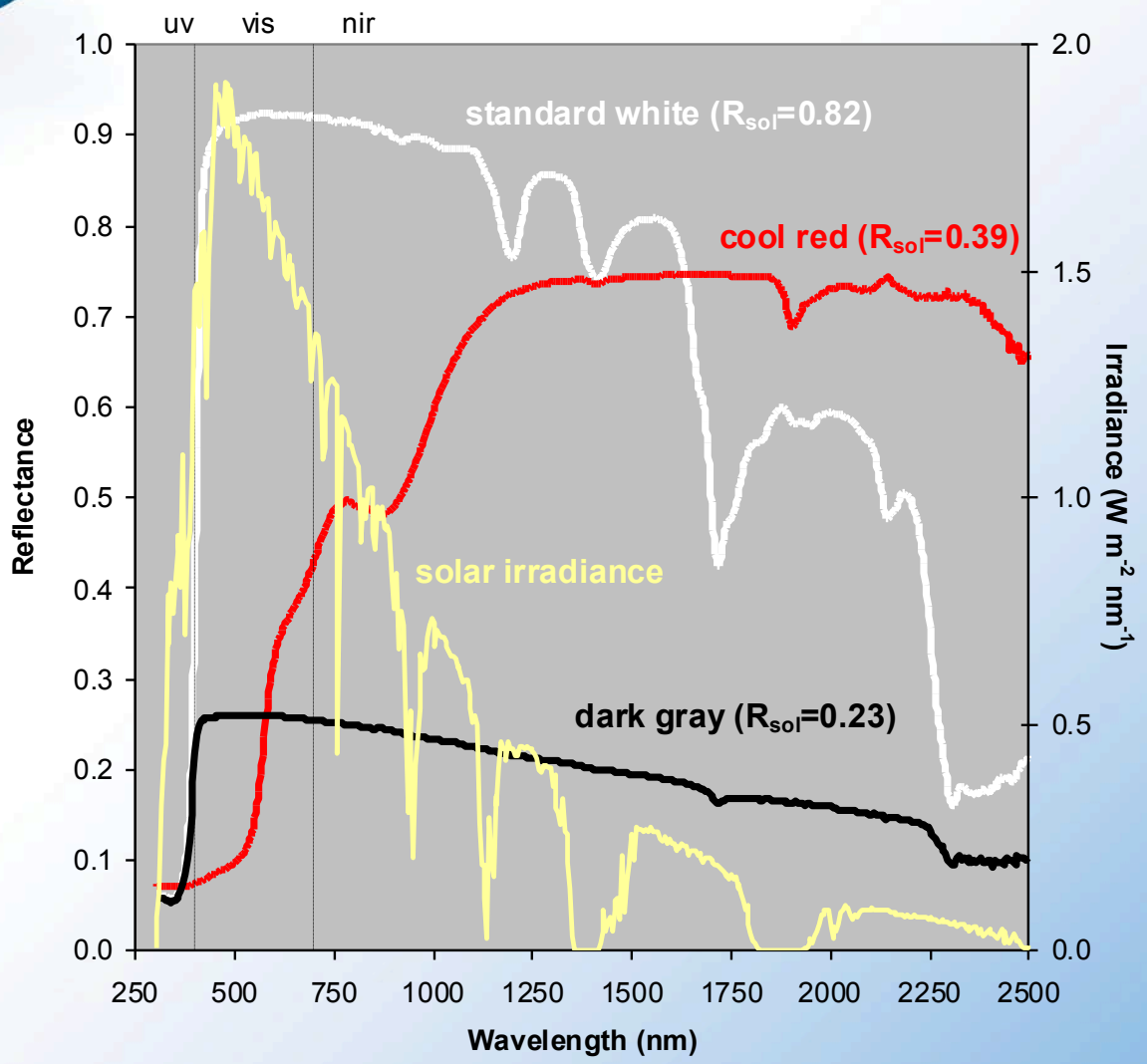
Sunlight — more than meets the eye



White, cool color, warm color



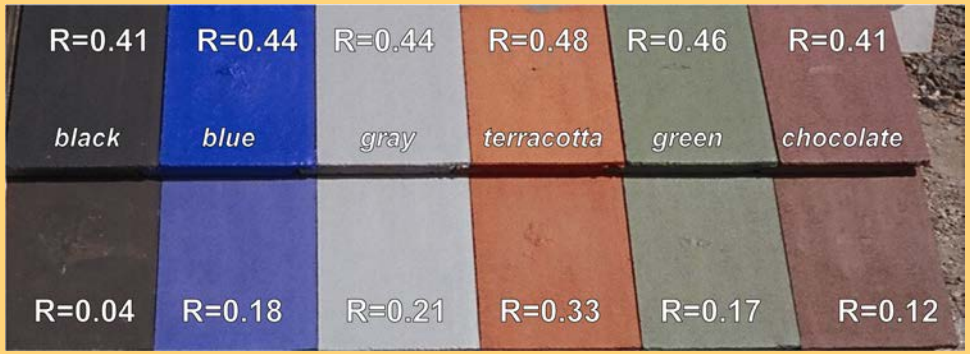
white roof

cool red roof

gray roof

Cool-colored roofs available today

cool concrete tile
SR ≥0.40



Courtesy
American
Rooftile
Coatings

standard concrete tile
(same color)

solar reflectance gain = +0.37 +0.26 +0.23 +0.15 +0.29 +0.29

cool clay tile
SR ≥0.40

Courtesy
MCA Clay Tile

cool metal
SR ≥0.30

Courtesy
BASF Industrial
Coatings

cool fiberglass asphalt shingle
SR ≥0.25
Courtesy
Elk Corporation